Electromigration in passivated Cu Interconnects studied by Transmission X-ray Microscopy

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The interconnect structures in advanced microelectronic devices currently have dimensions down to about 200 nm, and operate at very high current densities without excessive Joule heating. One of the major reliability-limiting failure mechanisms is electromigration (EM). This material transport can result in voids in the interconnect leading to open circuit failures as well as hillocks which extrude from the original interconnect causing short circuits. EM is one of the principal factors limiting microprocessor performance. In a passivated interconnect the mass flow due to EM is constrained by encapsulation. This leads to a high mechanical stress in the interconnect which influences the material transport significantly. Therefore, EM should be studied *in situ* using an intact interconnect system including barriers and passivation layers.

For this purpose an imaging technique is required which maintains high spatial resolution when penetrating through several microns of dielectrics. Due to the high penetration power of X-rays through matter and its high spatial resolution, X-ray microscopy overcomes several limitations of conventional microscopic techniques. It utilizes the natural absorption contrast between the elements of interest, i.e. Cu interconnects embedded in dielectrics. To penetrate passivation layers and Si layers up to 30 µm thickness, the photon energy range of the full-field transmission X-ray microscope XM-1 installed at the ALS in Berkeley was extended to 1.8 keV. Fig. 1 shows buried Cu interconnects connected with a Cu via of 300 nm in diameter imaged in the X-ray microscope. For comparison the same region was imaged in a standard SEM. The images clearly demonstrate the advantage of the X-ray microscope to investigate defects in buried structures with high spatial resolution and material contrast. We will present first EM results which also reveal the potential of X-ray microscopy as an important new tool to study mass transport phenomena and which allows investigation of failure mechanisms in electronic devices.

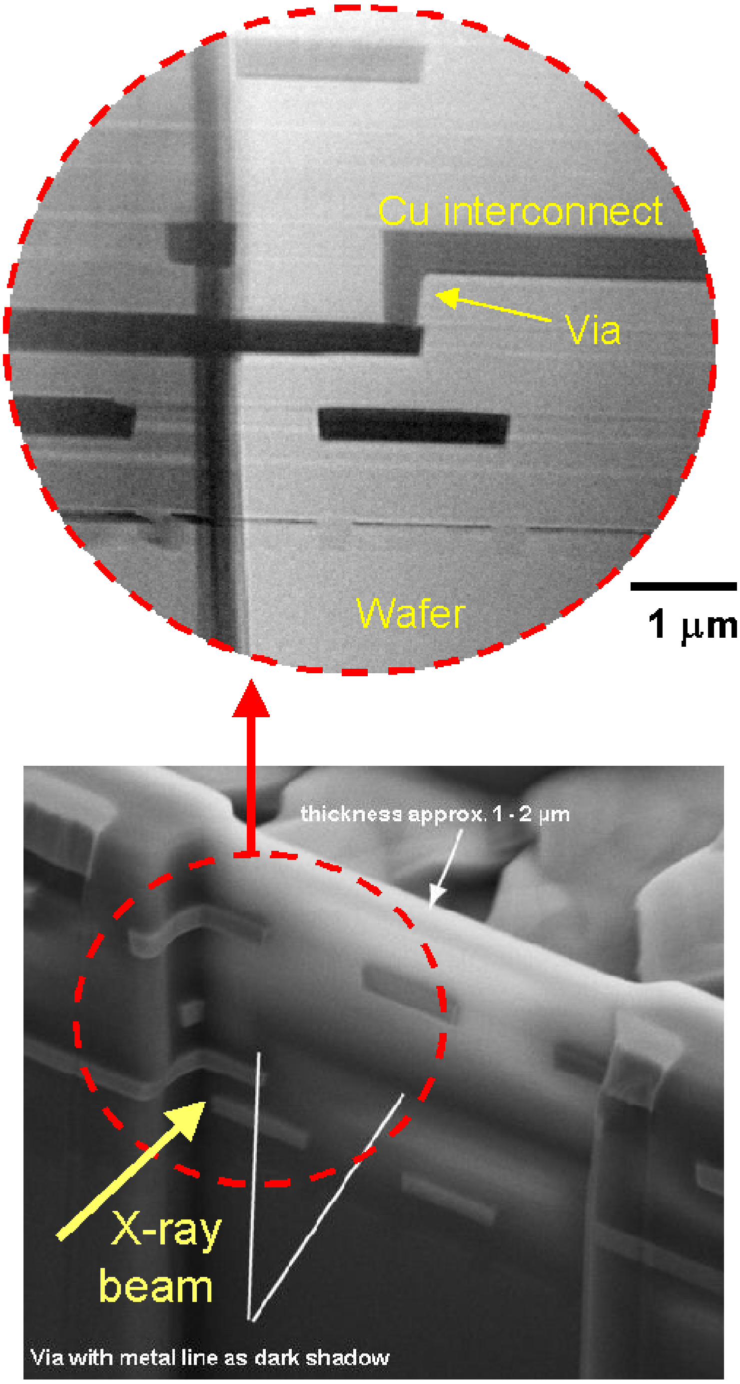

Fig. 1: SEM micrograph (lower) and X-ray micrograph (upper) imaged at 1.8 keV photon energy of a passivated Cu interconnect layer system.